U.S.F.W.S.
505 SK361
A257t
#505

Spiny Lobster Explorations in the Pacific and Caribbean Waters of the Republic of Panama

by Johnny A. Butler and Norman L. Pease

LIBRARY
NOV - 1 1965
FISH & WILDLIFE SERVICE

SPECIAL SCIENTIFIC REPORT–FISHERIES No. 505

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

UNITED STATES DEPARTMENT OF THE INTERIOR
Stewart L. Udall, *Secretary*
John A. Carver, Jr., *Under Secretary*
Stanley A. Cain, *Assistant Secretary for Fish and Wildlife*
FISH AND WILDLIFE SERVICE, Clarence F. Pautzke, *Commissioner*
BUREAU OF COMMERCIAL FISHERIES, Donald L. McKernan, *Director*

Spiny Lobster Explorations in the Pacific and Caribbean Waters of the Republic of Panama

By

JOHNNY A. BUTLER and NORMAN L. PEASE

United States Fish and Wildlife Service

Special Scientific Report--Fisheries No. 505

Washington, D.C.

July 1965

Digitized by the Internet Archive
in 2025

https://archive.org/details/noaa-technical-report-nmfs-ssrf_1965-07_505

CONTENTS

	Page
Introduction	1
Vessel, equipment, and gear	1
Vessel and vessel equipment	1
Fishing gear and equipment	3
Reed traps	4
Wire traps	4
Wood traps	5
Buoys, floats, and lines	5
Plastic traps	7
Lobster trawl	7
Fishing methods	7
Setting out	8
Retrieving and hauling	8
Handling traps from the launch	9
Obtaining bait	9
Survey areas	9
Selection of areas for exploration	9
Exploratory fishing coverage	9
Exploratory fishing results--First year	9
Caribbean (Atlantic) explorations	9
Pacific explorations	12
Gulf of Chiriqui	12
Gulf of Panama	12
Other Pacific areas	12
Explorations for lobsters with trawls	12
Trawling for bait	12
Miscellaneous catch components	13

Page

Environmental factors influencing catch 13

Bottom conditions. 14

Illumination. 14

The trap environment 14

Simulated commercial fishing--Second year 15

Lobster trapping 17

Lobster trawling 18

Panama bay scallops. 18

Biological notes on Panamanian lobsters 19

Spiny lobster - life history notes. 20

Pacific spiny lobster (Panulirus gracilis). 20

Caribbean spiny lobster (Panulirus argus) 23

Pacific sand lobster (Evibacus princeps) 24

Summary 25

Acknowledgments 26

Literature cited 26

Spiny Lobster Explorations in the Pacific and Caribbean Waters of the Republic of Panama

by

Johnny A. Butler and Norman L. Pease
Fishery Methods and Equipment Specialists
Bureau of Commercial Fisheries Exploratory Fishing Base
Pascagoula, Miss.

ABSTRACT

An interagency agreement, signed in June 1962, between the U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, and the U.S. Agency for International Development brought into being a survey of the spiny lobster potential in Panamanian waters. Bureau staff members used the chartered vessel Pelican. Explorations in 1962 were carried out in both Caribbean and Pacific waters with wood, reed, and wire traps. Wood traps proved more economical and successful. Bait for the traps was obtained locally. Indications of commercial potential were gained. During 1963 work included simulated commercial fishing with traps and trawls. Excellent catches resulted. In addition to spiny lobsters, sand lobsters and bay scallops were found in sufficient quantities to start a new Panamanian industry.

INTRODUCTION

In 1961, the U.S. Agency for International Development (US/AID) financed a Bureau of Commercial Fisheries study of the feasibility of developing the fisheries of the Republic of Panama. The study team found definite possibilities for developing and expanding the utilization of two resources, sharks and spiny lobsters.[1] The team recommended that further efforts be made to determine the potential of the lobster resource for expanded commercial fishing. As a result, US/AID entered into additional negotiations with the Bureau, and an interagency service agreement was signed June 1962,[2] calling for a 1-year exploratory fishing survey of the spiny lobster resource in Caribbean and Pacific waters.

The Bureau, through its Region II Exploratory Fishing and Gear Research staff, assembled the necessary personnel from Bureau programs, and a contract was awarded for the charter of the vessel Pelican. Simultaneously, purchase, fabrication, modification, and installation of necessary gear and equipment was carried on. The Pelican left the United States early in August, and the first exploratory cruise in Panamanian waters began on August 30, 1962.

After 10 months of exploratory lobster fishing, a meeting was called by US/AID to discuss the progress made by the program and to determine any future action. Representatives of the Bureau, US/AID, the Panamanian Government, and the Panamanian fishing industry attended the meeting, held in Panama City, Panama, on May 13, 1963. Owing to the degree of local interest in the results achieved thus far, a 1-year's extension of the agreement was approved.[3]

US/AID had requested the Panamanian fishing industry to provide some tangible indication of project support. The exact form this was to take was never agreed to; and when it became apparent that no agreement with industry could be reached, the project ended December 21, 1963.

VESSEL, EQUIPMENT, AND GEAR

Vessel and Vessel Equipment

The 72-foot Pelican (fig. 1) is a typical, steel-hulled Florida-rigged shrimp trawler, similar in design and general layout to vessels currently in use in Panamanian waters (fig. 2). Bullis and Rathjen (1959) have described this

[1] A Program for the more effective use of Panama's fishery resources, PIO/T525-29-060-10037, Washington, June 30, 1961 (mimeographed report from the Bureau of Commercial Fisheries to the U.S. Agency for International Development).

[2] PIO/T525-R-79-RA-3-20028 signed June 21, 1962.

[3] PIO/T525-W-29-AH3-30015 signed June 27, 1963.

Figure 1.--The Pelican modified for spiny lobster explorations in tropical waters. Lobster traps are carried on the main deck aft and on upper deck behind the flying bridge.

Figure 2.--A typical Panamanian shrimp trawler hauling back its net. Fishing boats of this class could readily be adapted for lobster trawling.

vessel, which the Bureau chartered in 1956 for explorations off the east coast of Florida, Georgia, and the Carolinas. Its original 170-hp. engine had been replaced by a slightly more powerful one a short time before it was rechartered for the lobster work. The vessel was slightly modified for lobster fishing. A flying bridge was installed, complete with controls; air conditioning was added; and extra electronic equipment was mounted (radar, two lorans, transistor radio-direction finder, single-side band and citizen-band radio sets, and two additional depth recorders). Davits were erected on the vessel's stern for carrying the launch. A hydraulic trap hauler was obtained and fitted to a boom tip at the port waist of the Pelican (fig. 3). The vessel has sufficient fuel and water capacity for a range of 2,500 miles or period of 21 days. A total of 185 traps can be carried on the main deck and behind the flying bridge, and below-deck storage is adequate for handling the requisite buoys, lines, trap weights, and miscellaneous fishing equipment and ship's stores. Provision is also made for freezing and storing the lobster catch. Accommodations are provided for 10 persons. During the survey, the Pelican was operated by the captain, a four-man crew, and two fishery specialists. Remaining accommodations were generally filled with observers from industry or fishery stations or with other interested persons.

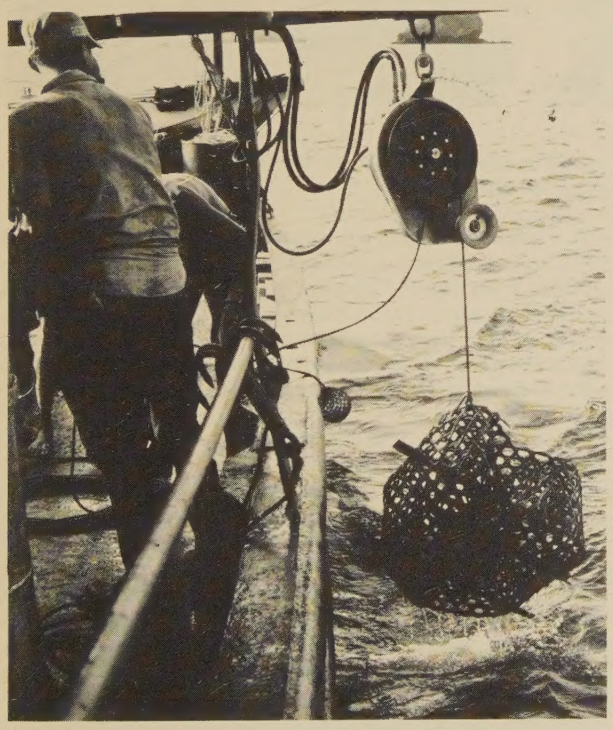

Figure 3.--Hydraulic trap hauler in operation. A reed trap is being hauled. The grapnel hanging on the rail is used to pick up trap buoys at the start of a hauling operation.

Figure 4.--Launch used in the survey to set and haul traps in shallow-water areas.

A 17-foot fiberglass launch (fig. 4) was acquired and modified for lobster fishing by adding a flat deck space forward of the controls to carry 15 to 25 traps. First powered by two 18-hp. out-board motors, it later was repowered with one 40-hp. motor. When not in use, the launch was carried in stern davits on the Pelican or towed astern. Use of the launch made it possible to set a maximum number of traps during the survey and permitted fishing in areas close to shore and reefs.

Fishing Gear and Equipment

Prior to the start of operations, we decided to confine fishing efforts to one basic type of gear. Only in this way could meaningful comparisons be made among the several fishing areas. The gear selected as basic was the lobster trap. The selection was based on a number of factors, among them: (1) The adaptability of traps to either large-scale or small-scale fishing operations; (2) the demonstrated success of traps in spiny lobster fisheries in warm waters the world over; (3) the combination of conveniently small individual units of effort and large number of units of effort made possible with traps; and (4) the possibility of contributing to the local economy by establishing small industries to construct, repair, and supply traps. Although other gear was used during 1962 on occasion (trawls and SCUBA gear), traps were used almost exclusively. Traps used were constructed of three materials--reeds, wire, and wood. The wood traps were not only more effective but also more economical in that they had longer

Figure 5.--A reed trap being taken aboard the Pelican. The 1- by 2-inch wood laths on top and bottom are useful for handling and stacking the traps.

useful life and required less repair. They were also relatively easy to stack and carry and could be made by local labor.

Reed traps.--Reed traps (figs. 3 and 5), popular in many parts of the Caribbean, are woven in three sections from cane strips. Top and bottom sections are identical, roughly 32 by 36 inches. Trap sides are formed by bending the third section, measuring about 14 or 18 inches wide and 132 inches long, to form a rounded rectangle and then bending the adjacent edges in and fastening a funnel between them. The funnel is woven separately and is usually about 14 inches across on the outside and 6 inches at the inner end. Top and bottom are attached to the sides with baling wire. One end of the top is left loose for inserting bait and removing the catch. Wooden slats (fig. 5) are wired to top and bottom to facilitate handling and stacking, and a concrete weight is fastened in the bottom so that the trap will sink upright. The amount of concrete used varies with the strength of the current at the fishing site.

The useful life of reed traps, when compared to that of either wood or wire traps, is extremely short. Repairs became necessary after 2 or 3 months' use, and after 4 months the reed traps had to be discarded. In addition, as they aged, the traps were especially susceptible to damage by sharks and other large fish.

Wire traps.--Wire traps (fig. 6) used measured 14 by 36 by 36 inches and were constructed from 3/4- or 1-inch hardware cloth.

Two 64-inch pieces of 36-inch hardware cloth are cut; each end is bent up 90°, 14 inches back; and the two are wired together at right angles to form a rectangle. A section of either top or side is then cut out, and the funnel is inserted and wired in place. Top funnels are 8-inch squares open on both ends. Side funnels are made from two triangular pieces of hardware cloth, 4 by 18 inches, wired together to form a funnel-shaped opening, which is about 14 inches across at the outer end and 6 inches at the inner. Finally, a hinged opening is made in the top panel by cutting along three sides of an area large enough

Figure 6.--A wire trap being hauled. This trap is fitted with a side funnel made of woven reeds. More usual practice was to make the funnel of hardware cloth. In some traps, the funnel was in the top panel, rather than in the side of the trap.

Figure 7.--Wood trap being hauled. The funnel can be seen in the center of the trap top. Wood traps produced higher catches than either wire or reed and required less upkeep.

for removal of the lobsters and insertion of bait. Weights are generally placed in the trap, on the bottom panel, to keep it upright.

Wood traps.--Wood traps (figs. 7 and 8) proved the most successful during the period covered by this report. The traps used are identical to those used in the Florida spiny lobster fishery (Cope, 1959). They are built of wood slats and measure 2 by 3 feet at the base. The sides slope in so that the top is somewhat smaller. Each trap is about 18 inches deep and is furnished with an 8-inch square funnel mouth on the top of the trap with the funnel extending 6 inches into the trap. This opening is used for baiting and removing the catch as well as for an entrance for the lobsters. Initially, cement blocks, 3 by 8 by 8 inches and weighing roughly 16 pounds each were wired to the bottom of the trap for weight; however, concrete poured into partitions provided on each end of the trap proved more efficient. The amount of weight necessary to properly settle a trap depends on the ability of its wood to absorb water and the velocity of the currents in the fishing area. Usually about 30 to 40 pounds is sufficient to ensure upright sinking of a new trap.

Buoys, floats, and lines.--Marking the location of and retrieving the traps are accomplished with a system of buoys, floats, and lines (figs. 9-11) The buoys and floats can be made in a variety of ways from a number of materials. Those described herein, however, proved suitable during the survey and are recommended for maximum ease of operation.

To make a flag buoy, two or three 8-penny nails are driven partially into a 40-inch broom or mop handle a few inches from one end. That end is then set in a pint milk carton, and the carton is filled with cement. A minimum of three 6-inch squares of 2-inch styrofoam is then threaded onto the pole and fastened with tarred twine a little more than halfway down the pole. Encasing the styrofoam in a plastic bag helps protect the edges. The pole is painted with fluorescent orange paint above the styrofoam, and a flag is attached to the top for visibility.

Each flag buoy is provided with a 2-fathom length of No. 42 seine twine, which is doubled and secured to the pole above and below the styrofoam. A 5-inch round styrofoam float is tied to this line about 6 feet from the flag buoy to help float the main buoy line away from the trap and to provide a well-marked target area for throwing the grapnel as the first step in retrieving the trap.

Each trap or string of traps is also provided with a 3- by 4-inch cylindrical plastic float which is threaded onto the main buoy line from

Figure 8.--Lobsters are removed through the funnel opening in the top of the trap.

Figure 9.--Flag buoy, plastic float, and lines used to mark and retrieve traps. Cement block trap weights are lined up along the rail in the background.

the end that will be attached to the trap. The float keeps the buoy line away from the trap. It is threaded loosely on the line, rather than being tied, so that it will not interfere when the buoy line is bent over the line hauler. Main buoy lines are 5/16-inch manila, sisal, or 1/4-inch synthetic-fiber lines that are made up in 10-, 15-, or 20-fathom lengths and adjusted to the water depth at the fishing site. A large knot is tied in the line about 1 fathom above the trap. This is done to restrict the threaded plastic float so it will keep the buoy line from becoming entangled in the trap.

Plastic traps.--Experimental plastic lobster traps were used unsuccessfully. The first to be tried was fabricated from 1/4-inch acrylic plastic. This material proved to be too brittle to withstand the normal usage given to fishing gear and had to be discarded. The second type plastic, a flexible polyethylene of European design, was made into a trap consisting of two halves which interlocked (fig. 10). A circular funnel was located in the center of the upper half. One 10-pound cement block, secured to the bottom of the lower half, was sufficient to settle the trap on station. Unfortunately, the polyethylene was readily ripped by sharks, and its use was discontinued for that reason.

Lobster trawl.--Lobstering during Pelican cruise 16 was carried out with a 40-foot

Figure 10.--An experimental, molded, polyethylene lobster trap used unsuccessfully in Panama. Its use was discontinued because of shark damage.

shrimp trawl with plastic mud rollers and a tickler chain. Twenty-two 9-inch rollers were strung on a 1/4-inch nylon line, which was seized to the footrope between each roller. The 1/4-inch tickler chain was cut 1 foot shorter than the corkline of the net and was shackled to the lower rear bracket of each door.

FISHING METHODS

For convenience in maintaining records of catch data, six traps per station were set. Stations were numbered in numerical sequence with individual position, air and water temperature, salinity, etc. recorded.

Traps were stacked three high on the decks of the Pelican, each with its buoy line attached and coiled on top so that it would run out freely during the set. The wood traps, being heavier, were stacked on the main deck; the wire and reed traps were carried on the upper deck. The flag buoys were either carried below or lined up along the rail. In pure exploration, suitable bottom was found by running transects

Figure 11.--Pelican approaching a trap set. A grapnel is thrown between the flag buoy and the float to snag the flag buoy lead line. The buoy is then hauled aboard and the main buoy line is bent on the hydraulic hauler.

with the depth recorder and noting bottom configuration. Positions fished previously with success were found again by using loran, radar, depth recorder, and navigational charts.

Setting Out

On the grounds, the flag buoy lines are attached to the main buoy lines and are thrown over the side. The main buoy line is allowed to pay out after the flag buoy and become taut in the water behind the vessel to lessen the likelihood of tangles and knotting. Then the trap is dropped. Generally, each trap is connected to a flag buoy. Sometimes, however, multiple sets are made. Main buoy lines of two to six traps are connected together, and a flag buoy is fastened to the first trap only. Setting and hauling traps connected this way is somewhat quicker than handling single traps, but the losses experienced from parted buoy lines are higher, and more serious.

Retrieving and Hauling

The vessel approaches the flag buoys so that the hauler on the port side is adjacent to them (fig. 11), and a grapnel (fig. 3) is thrown between the flag buoy and its float to snag the flag buoy line. The flag buoy is then brought aboard manually, detached from the main buoy line, and stored ready for the next set. The main buoy line is reeved in the hydraulic block and brought aboard. As it comes aboard, it is coiled for the next set. When the trap comes aboard (figs. 3, 5, 6, 7, and 8), the catch and any old bait remaining are removed and fresh

bait is added. The traps are then stacked with their buoy lines coiled on top, ready for resetting.

Five men handle the operation aboard the Pelican: The captain handles the vessel; a second man throws the grapnel and handles the controls of the hydraulic hauler; another man detaches the flag buoy and coils the buoy lines as they come aboard; and the remaining two store the flag buoys, remove the catch and old bait, add fresh bait, and repair and stack the traps. Using this system and making allowance for traveling the varying distances between fishing locations, 200 traps a day can be handled.

Handling Traps from the Launch

Trap handling from the launch is similar to that just described, except that the traps are hauled by hand, and fewer men are used. Fifty or more reed or wire traps, and a somewhat lesser number of the heavier wood traps, can be set and hauled in a day from the launch.

Obtaining Bait

Bait was taken by trawling with standard 40-foot, semiballoon trawls of the type described by Bullis (1951), by trolling, by longlining (for sharks) with a 10-hook unit of Japanese tuna longline gear, described by Captiva (1955), and by handlining with or without use of night-lights. Once obtained, the bait was strung on soft baling wire and tied inside the traps. Small fish were used whole; larger fish were cut up before use.

SURVEY AREAS

At the start of operations, it was obvious that one vessel could not survey adequately the entire Panamanian coast on both sides of the Isthmus in the time limits imposed by the contract agreement. A type of sampling therefore was needed.

Selection of Areas for Explorations

A number of areas were, therefore, selected prior to field operations on the basis of (1) existence of small-scale lobster fisheries in progress; (2) suitable habitats for lobsters as judged by chart indications of reefs, island areas, coral, or rock bottom, and discussions with fishermen, and (3) proximity to handling facilities, vessels, and a sufficient population so that the exploratory results obtained could be utilized with the minimum of shifts of people and supplies. Since most of the lobsters caught would be shipped to or through Panama City, proximity to market was a factor considered, but not given especially great weight in selection of survey areas.

Exploratory Fishing Coverage (fig. 12)

The Pelican made seven cruises on the Pacific coast and four on the Caribbean coast. This unequal distribution of effort was necessary because of highly adverse weather and sea conditions in the Caribbean in winter 1962-63. The Caribbean effort was, therefore, restricted to the San Blas Islands area, where the environment appeared to favor lobster abundance, and the waters around Bocas del Toro Channel where there was small-scale lobster fishing and where it seemed likely that increased fisheries would be stimulated if the explorations were successful. Indications had also been received that the profitable Costa Rican fishery for lobsters extended toward the Bocas del Toro area.

In the Pacific, attention was at first focused on two areas--the Gulf of Panama and the Gulf of Chiriqui. The first was chosen because of its nearness to Panama City, the number of vessels and fishermen in bordering communities, and indications from the fishermen that lobsters occurred, at least seasonally. The second area was chosen after an examination of charts showed indications of suitable lobster habitat and access to processing and marketing facilities.

The additional time allotted the Pacific, owing to bad weather in the Caribbean, was spent in extending exploratory coverage towards Colombia and Costa Rica.

EXPLORATORY FISHING RESULTS--FIRST YEAR

In the first year of operations (August 30, 1962, to June 30, 1963), 11 cruises of the Pelican were completed in 161 sea days (fig. 12). Seven of these cruises were in the Pacific Ocean, where the primary target was the Pacific spiny lobster (Panulirus gracilis); the remaining four were in the Caribbean Sea, where the Caribbean spiny lobster (P. argus), was sought. During the cruises 1,071 fishing stations were occupied, most of them with traps. In all, 5,417 successful trap sets (table 1) were made, representing a total cumulative effort of 12,039 trap fishing nights. In addition, 214 traps were set but not recovered and 131 traps were known to have been malfunctional, owing either to trap damage or improper setting.

Caribbean (Atlantic) Explorations

Areas surveyed include those near and about the San Blas Islands (cruise 5) and in the Bocas del Toro Channel area (cruises 4, 12, and 13).

Fishing in the Bocas area in April resulted in catches averaging one lobster per 3 trap

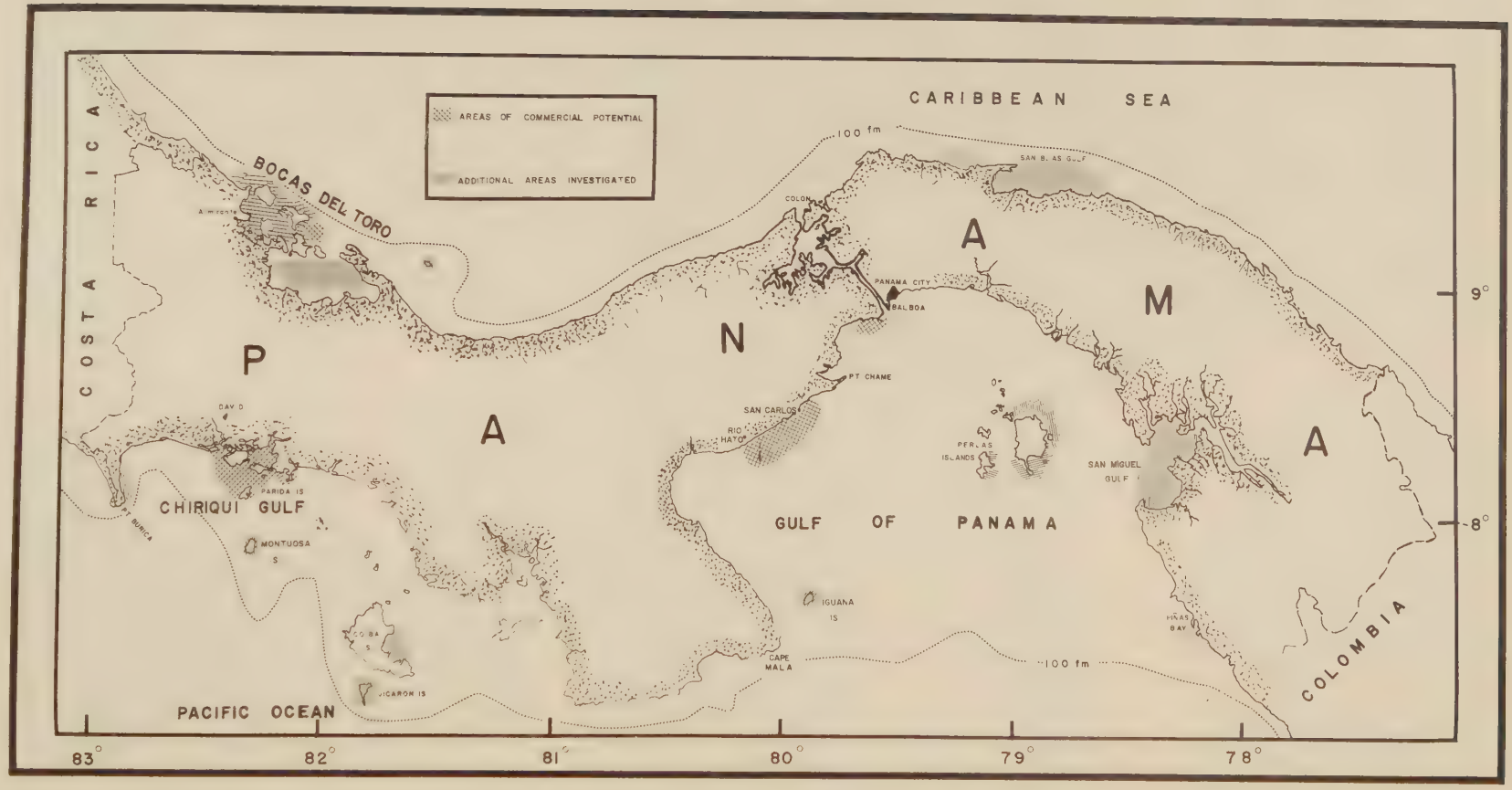

Figure 12.--Chart of Panamanian region showing areas of commercial lobstering potential and all other areas investigated.

Table 1.--Trap types, effort, catches, and catch per unit of effort--spiny lobster explorations, August 1962 to June 1963, Panama

Effort, catch, sets	Type of traps						
	Wood		Wire		Fiber		Total
Pacific cruises:	Number	Percent	Number	Percent	Number	Percent	Number
Effort, trap nights..	4,139	47	3,287	37	1,339	15	8,875
Catch P. gracilis....	977	61	388	25	223	14	1,588
Catch per unit of effort.....	0.231	46	0.121	23	0.159	31	-
Caribbean cruises:							
Effort, trap nights..	1,664	53	1,343	42	154	5	3,161
Catch, P. argus.....	468	67	233	32	2	1	703
Catch per unit of effort.....	0.281	60	0.173	37	0.012	3	-
All cruises:							
Effort, trap nights..	5,863	49	4,623	38	1,553	13	12,039
Catch, all lobsters..	1,483	65	628	27	225	8	2,291
Catch per unit of effort.....	0.252	48	0.135	25	0.144	27	-
Traps sets.....	2,903	50	2,211	38	648	12	5,762
Traps fishing successfully.....	2,693	51	2,133	39	591	10	5,417

nights of fishing effort in the course of purely exploratory operations (not to be construed as equivalent to commercial or production type operations). In May, averages were lower (one lobster per 5 trap nights fishing), but one 72-trap set, fished 2 nights, took 72 lobsters. Again, this was in the course of exploratory fishing, and actual commercial catch rates should be higher.

Catch rates in the San Blas area were consistently low during the brief period of investigation allotted. This period, however, was devoted to gear trials as well as explorations, and additional coverage should be given this area. At least in the fall, present indications are that the potential of the San Blas area is lower than that of the Bocas area and the potential for trap fishing in that season may well be limited to small-scale operations.

Pacific Explorations

Cruises 6, 7, 8, 9, 10, 11, 12, and 14 were in the Pacific waters. Areas surveyed include: The waters off Panama City and Balboa (cruise 6); the Chiriqui Gulf (cruises 7, 9, 10, and 11); near the Perlas Islands (cruises 6 and 8); from Cape Mala to Montuosa Island (cruise 7); in the Gulf of San Miguel (cruise 8); in Pinas Bay, and in the Gulf of Panama (cruises 11 and 14). In the Pacific, two areas appear to stand out as having the highest potential for lobster trap fishing. These are the Gulf of Chiriqui and the northwestern portion of the Gulf of Panama in the Pacific.

Gulf of Chiriqui.--The potential of the Gulf of Chiriqui was examined during October, November, January, February, March, and April (a cruise to the Gulf in September was devoted to gear and equipment familiarization only). Average catch rates per cruise varied from slightly over one lobster per 2 trap nights fishing, to about one lobster per 7 trap nights fishing. These averages, however, were the result of pure exploratory fishing, not commercial trials. In the small amount of simulated commercial fishing that was accomplished in the time allotted, the catch rates resulting rose to averages of one to one and a half lobsters per 2 trap nights, and even these averages are not actually indicative of the best that a commercial venture could do, for such factors as the effect on catch of variable spacing of traps were being investigated during the simulated commercial trials. Best season in the Gulf of Chiriqui appears to be fall (October-November), although more work must be done in the months not surveyed.

Gulf of Panama.--The potential of the portion of the Gulf near Rio Hato-San Carlos was surveyed in June 1963. At this time, during purely exploratory fishing, catch rates approached one lobster per trap day. In Santelmo Bay, Perlas Islands, a rate of slightly less than one lobster per 2 trap nights was achieved in limited fishing in December.

Other Pacific areas.--Catch rates in other portions of the Pacific investigated for short periods ranged from nothing to one lobster per 15 days. Areas not producing lobsters, or only producing them in small numbers, and the months in which they were investigated are as follows: Off Panama City and Balboa (October and November); off Point Chame, Cape Mala, Jicaron Island, and Montuosa Island (October and November); near San Jose Island in the Perlas group, and in San Miguel Gulf (December); Pinas Bay (December); and near the Rio Hato-San Carlos area, Gulf of Panama (June).

Explorations for Lobsters with Trawls

An insufficient amount of trawling was accomplished during the first year to allow proper evaluation of the trawl potential. Thirty drags with 40-foot shrimp trawls in the Gulf of Panama caught 82 spiny lobsters (P. gracilis) (figs. 13 and 14), and 326 sand or Chinese lobsters (Evibacus princeps) (Fig. 15). The latter were found to be of excellent eating quality and are caught infrequently in traps. Best trawling area found to date appears to be in the Rio Hato-San Carlos portion of the Gulf of Panama where 241 sand lobsters and 62 spiny lobsters were taken in 10 drags averaging 75 minutes each.

Trawling for Bait

Bait for lobster traps is a serious problem in many of the areas of Panama where lobster trapping has been carried on. Indeed, in some

Figure 13.--Pacific spiny lobster (Panulirus gracilis).

Figure 14.--Catch of Pacific spiny lobsters aboard the Pelican.

sections bits of broken, white china have been used as bait substitutes. In the course of the surveys reported herein, however, the Pelican used a shrimp trawl to obtain bait readily in most areas.

Because a trap fishery could be developed successfully in a given area only if bait were available, bait surveys were considered an integral part of the lobster explorations. Bait used, in every instance, was taken in the area in which the traps were fished. On the Pacific side, 1- to 2-hour drags of the 40-foot shrimp trawl generally resulted in 200 to 300 pounds of small, mixed bottomfishes suitable for bait; hence bait would not be a limiting factor in developing a fishery. On the Caribbean coast, trawling was less successful. In the Bocas area, bait trawling was impractical during the period of investigation, because of the limited amount of bottom sufficiently smooth to allow trawling, combined with the difficulty of trawling in the rough weather that prevailed. The bait problem there was solved satisfactorily by catching sharks with longlines.

Miscellaneous Catch Components

Although the project was established to determine the potential of the spiny lobster resource, note was made of the other animals taken in traps, longlines, and trawls during the field work. Among those of possible commercial significance were Chinese or sand lobsters, shrimp, scallops, foodfish, and sharks.

Figure 15.--Pacific sand lobster (Evibacus princeps), a female with eggs.

The shrimp resources of the Pacific waters of Panama have been studied extensively, and catches made there were for the most part taken on well-established commercial grounds. In the Caribbean, however, less study has been devoted to shrimp. In the course of trawling for bait, small numbers of shrimp were taken on both the San Blas and Bocas grounds. Small numbers of white and brown shrimp (Penaeus schmitti and P. braziliensis) were taken in Chiriqui Lagoon in depths less than 10 fathoms. Farther north, off Icocas Island (Bocas area) 50 and 60 pounds of mixed brown and pink (P. duorarum) shrimp were taken in two bait drags. The possibility exists for a commercial shrimp fishery in this area.

Foodfish occurred in most bait drags, particularly in the Pacific. An excellent potential for development of a foodfish fishery appears to exist in the Rio Hato area of the Gulf of Panama where five drags in shallow water caught from 1,500 to 3,000 pounds of edible fishes, mostly large croakers. The small amount of shark longlining done invariably resulted in good catches. A definite potential exists for the development of a shark fishery, as suggested by the Bureau study team in 1961.

Environmental Factors Influencing Catch

Records maintained during the field work included not only fishing effort and catch, but also certain environmental data of the type that experience in fishery explorations elsewhere had shown to be important in interpreting fishing results. Unfortunately, complete analysis of the effects of these factors is not possible, partly because of the short duration of the work period reported on here and partly because of the necessity for covering

so wide a total area that sequential observations could seldom be made in one place. The paragraphs that follow present trends and correlations that are allowed by the data available.

Bottom conditions.--Lobsters were taken on widely diverse types of bottom--coral, rock, sand, grass, and shell--but showed a preference for spots near some type of concealment. There was no correlation between the degree of irregularity and the number of lobsters caught, except that sets made on and immediately adjacent to reefs caught fewer lobsters than those from 50 to a few hundred yards away from the reefs, in the reef foraging area. Farther from the reef, on bottom offering fewer hiding places than the intermediate area, catch rates again dropped off (fig. 16).

Other factors of the bottom environment associated with the presence or availability of lobsters include bottom temperature and salinity. Fishing was carried out over a total temperature range of 68° to 85° F. and a salinity range of 28 to 34 parts per thousand (‰). In general, best fishing was experienced in the narrower ranges of 83° to 85° F. and 31 to 32 ‰. The effect of temperature on trap catches was demonstrated graphically during sets made off Panama City just before and during a temperature decrease caused by a sudden influx of cold (68° F.) water. Prior to the influx, good catches were being made in traps set in water having temperatures of 81° to 82° F. As the cold water moved in, catches fell off, and at a temperature of 68° F., 237 trap nights of fishing effort in 8-10 fathoms failed to secure a single lobster. During the same period, local boys were able to catch spiny lobsters in unusually large numbers when skin-diving and even while wading in the shallow waters adjacent to the shoreline. Templeman (1940), when discussing the effect of cold water on the American lobster (Homarus americanus) found in the waters off northeastern United States and Canada, stated, "In very cold water, just above freezing point, very little if any feeding occurs and few lobsters can be trapped. As the water warms up, feeding increases and the lobsters trap readily." As spiny lobsters were being caught by hand and spear adjacent to the shoreline but not by traps in the 8- to 10-fathom depth range it was apparent the water temperature drop of 17° F. may have stimulated the lobsters to move inshore to more favorable temperatures.

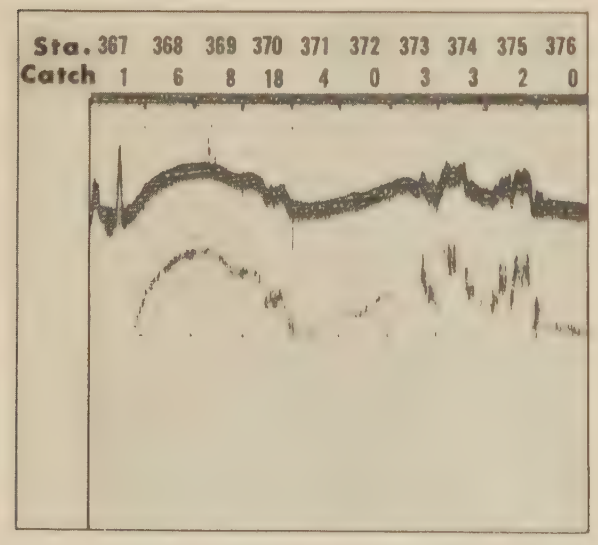

Figure 16.--Depth recorder tracing of a "typical" stretch of sea bottom with actual catches obtained from trap fishing indicated above.

In Panama, a common belief is that the Humboldt or Peruvian Current brings cold water into the Gulf of Panama during the dry season (January-March) and causes the water temperature drop mentioned here. In his study of the oyster resources of Panama, Galtsoff (1948) reports, "The presence of relatively cold water in the western part of the Gulf of Panama may suggest an upwelling along the submarine valley west of the Pearl Islands .... The suggestion that the difference in water temperature in the Gulf of Panama and Chiriqui Gulf is due to the influx of cold water from the Humboldt Current or from its branch known as the Galapagos Currents does not appear to be sound, for the latter current extends north only as far as 5° N. latitude and veers west."

The presence of 31 to 32 ‰ salinities is associated with areas receiving some runoff from bordering river systems. Around Montuosa Island, where conditions appeared favorable for lobsters, but where no runoff occurs, the catch was nil.

In the Panamanian waters, temperature conditions on the bottom proving optimal for trap fishing are often found at depths of 4 to 5 fathoms, though this varies from point to point, and the use of a thermometer for determining bottom temperatures would be profitable in a commercial venture.

Illumination.--Lobsters, being relatively defenseless, appear to move about more readily in the dark, and most fishing with traps was planned to include one or more nighttime periods. Comparisons of catches made on bright moonlight nights with those on dark nights without moon were made to determine the level of illumination at which most activity occurs. These, however, were not conclusive, owing in part to insufficient measure of cloud cover and water turbidity.

The trap environment.--The theory behind trap fishing is that the trap offers lobsters a place of concealment, or a supply of food, or

both. Thus, the trap is, in a sense, an artificially introduced part of the environment. Making a trap an acceptable part of the environment is essential to profitable fishing. Although unbaited traps catch those lobsters that are merely seeking concealment, baited traps are decidedly more effective. During the survey a wide variety of baits were successfully used--live and crushed conchs, small bottomfishes, shark, black skipjack, live lobsters, and bits of white china. The only preference indicated by the lobsters was for the cut bait to be fresh.

Conversely, the only bait, which was completely ignored by not only lobsters but also by fish and crabs that entered the traps, was a species of puffer, Sphaeroides annulatus. Halstead and Russell (1956) described two toxic substances, isolated from a related species found in Japanese waters, which when ingested by humans can cause illness within 30 minutes and possible coma and death within 1 to 24 hours.

Seasoning the traps, that is, allowing them to become coated with accumulations of slime, barnacles, and other natural growths, appears to make them more acceptable to lobsters. In explorations covering a wide area, it is not always possible to provide seasoned traps, because transport of traps on the deck of a vessel for a relatively long period kills the growths and negates the seasoning effect to some degree.

During one 13-day interval between cruises, however, wood traps were stored in the tidal waters of a cove on Parida Island. They remained completely submerged and became covered with an accumulation of growths, silt, and mud. When the traps were retrieved and the fishing resumed at the beginning of the next cruise, the catch rate was found to increase daily to the sixth day of fishing before leveling off, indicating a beneficial effect. Of some interest was a series of postlarval lobsters, presumably P. gracilis, which were found clinging to the above-mentioned, stored traps when they were retrieved.

To determine the effect of duration of setting, traps were hauled at intervals of 1 to 8 days. The results indicate that catch rates are slightly higher for traps fishing 2 to 3 days than for those hauled daily or left 4 or more days. These data were substantiated by Robinson and Dimitrou (1963) "...catch per trap-day or gear use efficiency, decreases as the time the traps are allowed to fish increases."

SIMULATED COMMERCIAL FISHING--SECOND YEAR

The early termination of the project and lack of sufficient personnel limited the work during the second year to only one of the three areas previously selected for investigation. This was the Gulf of Panama area, where two cruises (Pelican cruises 15 and 16) were made in the northwestern part of the Gulf of Panama before the termination date. On cruise 15 the lobster traps, which were used almost exclusively, produced 1,066 lobsters weighing 1,458 pounds. On cruise 16 the primary effort devoted to trawling produced 2,843 lobsters weighing 2,758 pounds.

On cruise 15, 4 bushels of bay scallops (Aequipecten circularis) were caught while trawling for lobster bait. A brief mention of the commercial potential of the scallops was included in Pelican 15 cruise report. Within 2 months a new fishery for scallops was developing, which employed 400 people and 15 vessels.

Incidental catches of marketable red snapper (Lutjanus guttatus), up to 65 pounds per drag, were taken in the trawl along with the lobsters and miscellaneous bottomfish.

Three private lobster trapping operations were in various stages of development when the project ended. One company completed the conversion of a 33-foot diesel powered boat (fig. 17). Another company had almost completed construction of a lobster pound (fig. 18), and was starting to set out traps. The third had recently acquired a 44-foot boat to be modified for lobstering.

There were two species of lobsters taken in the trawls: spiny lobsters (P. gracilis) and sand lobsters (E. princeps). The total catch of 2,843 lobsters caught during cruise 16 in trawls and traps consisted of 1,803 sand and 1,035 spiny lobsters.

A tabulation of the sex ratio of 877 trawl-caught and 302 trap-caught spiny lobsters was made for comparative purposes (fig. 19). The trap-caught ratio was 62 males: 38 females. The trawl-caught ratio was 32 males: 68 females.

Traps were fished in September, and trawls used in December. Because the depth, temperature, and salinity of the waters fished were similar in both cases, this seasonal difference is not considered significant. The only apparent variable that might account for the differences in the observed sex ratio was that the trawls were fished from 2 to 5 miles offshore whereas traps were used from 50 yards to 1 mile from either land or exposed rock formations.

Pelican cruise 15 produced 1,066 lobsters weighing 1,458 pounds. Pelican cruise 16 produced 2,843 lobsters weighing 2,758 pounds. Two factors accounted for this difference in number-weight ratio. First, trapping for lobsters produces a higher percentage of large male spiny lobsters (average weight 24 ounces). Second, trawling for lobsters, in addition to producing a higher percentage of the smaller female spiny lobsters (average weight 17 ounces), also results in about 60 percent of the catch being made up of sand lobsters whose weight (combined male and female) was 12 ounces.

Figure 17.--A 33-foot diesel powered boat being modified for spiny lobster fishing in a Panamanian boatyard.

Figure 18.--A lobster-holding pound in Panama waiting for high tide to be towed and anchored offshore. In the background are several wood-slat lobster traps.

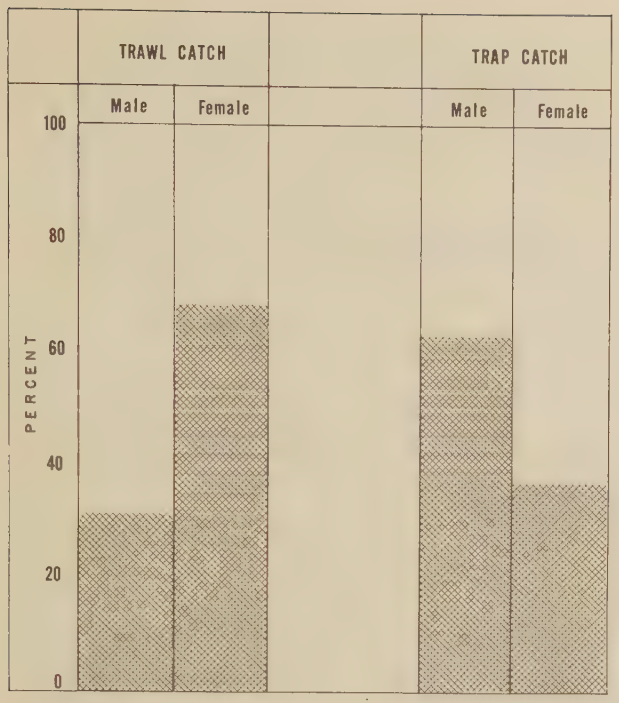

Figure 19.--Graph showing the inverse sex ratio between the trawl- and trap-caught Pacific spiny lobster (P. gracilis).

Lobster Trapping

In conformance with the plans, cruises simulated commercial fishing rather than pure exploration. To emphasize the possibility that a self-sustaining commercial operation could be worked on a small scale, cruise 15 was designed to approximate a one-boat, two-man trap-fishing operation with a string of 200 traps. As a result of information acquired during the first year of operation, the traps were distributed parallel with the coast and around small islands. Each day 100 traps of the 200 set were hauled, rebaited, and reset. After allowing several days for the traps to season, we watched for any noticeable trend in the catches. Several conditions seemed to affect the reactions of the lobsters in relation to their habitat. For example, it was noted that traps on the western side of the islands generally out-produced those set on the eastern side. This apparently was caused by a current flowing in a westerly direction in this area, making the western side of the island the lee or protected side, indicating that lobsters prefer relatively placid water conditions.

In addition to the effect of currents on lobster production, a temporary wind effect was observed (fig. 20). This occurred during September in the northwestern part of the Bay of Panama. The wind, which had been blowing lightly from the northwest, shifted to the south, increased in velocity to 15 or 20 knots,

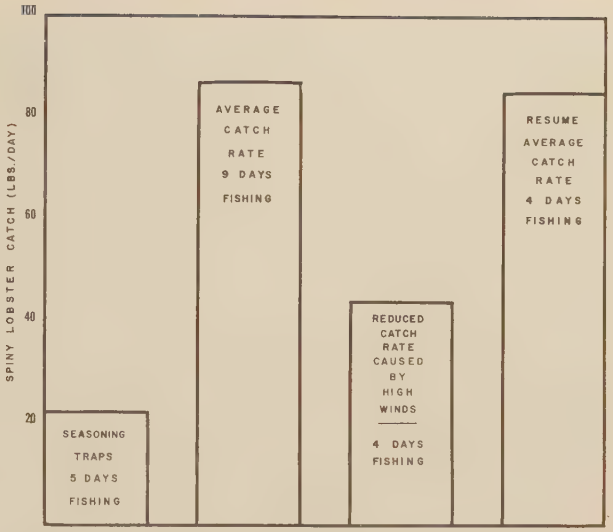

Figure 20.--Spiny lobster trap catch rates for a 22-day period showing adverse effect of unseasoned traps and strong winds.

and held for several days. During this time, the lobster catch rate dropped 50 percent. After the wind had moderated, the original catch pattern was gradually resumed. Specifically, the effect on the catch was as related in the following paragraphs.

The daily catch rate during the entire cruise varied from 20 to 109 pounds of lobster per 100 traps hauled. As 90 percent of the traps were new, it took about 5 days for the traps to season. During this time, the catch rate averaged only 22 pounds per day. During the 9-day period following seasoning, production increased to an average of 87 pounds per day. This represents slightly more than 3 pounds of lobsters per trap per week. Cope (1959) states that under favorable fishing conditions, Florida lobstermen expect a similar yield.

During the next 4 fishing days, the catch rate suddenly dropped to an average of only 44 pounds per day, apparently because of the shift in direction and increase in velocity of the wind. Subsequent conversations with local shrimp fishermen indicated that they too experienced poor fishing in this period.

In the final 4 days of the cruise, normal weather conditions returned and the catch rate climbed back to an average of 85 pounds per day.

The cruise results indicate that the spiny lobster population in the extreme northwest section of the Bay of Panama would support a commercial fishery. Further work would be necessary to determine the geographical limits of the lobster grounds and whether or not seasonal fluctuations occur. A reasonable estimate of potential lobster production from the area is dependent on answers to these tw factors.

Lobster Trawling

During the last cruise (Pelican cruise 16), trawling for lobsters was emphasized. The region selected was, in 5 to 10 fathoms, between Rio Mar and San Carlos--an area in which Pelican cruise 14 had shown that trawling might be feasible with proper gear. The bottom in this area was hard, with low-lying coral and rock covering the 14 square miles of area worked. Most of the rock and coral was too small to be detected on the vessel's depth recorder; however, large formations could be detected and avoided. The roller-rigged trawl proved to be capable of working the rough bottom encountered with only an occasional breaking of the tickler chain. Only one major tearup of the trawl occurred during 45 drags, and this was caused by a large rock. During early drags, several small holes were found in the bottom of the bag. These resulted from the heavy weight of the catch that caused the bag to bounce along the rough bottom. The condition was corrected by using chafing gear. Except when hangups occurred, drags were 90 minutes long.

Lobster trawling catches varied from 10 to 210 pounds. Relative numbers of the two species of lobsters taken also varied among drags. Composition of the total catch for the cruise, however, was about 60 percent sand lobsters (E. princeps) and 40 percent spiny lobsters (P. gracilis).

One of the unexpected results of the lobster dragging was the number of sand lobsters caught. The species had been caught rarely in the lobster traps and only occasionally in the trawls during bait dragging. Local fishermen realized this lobster was present, but they did not know in what amount and had not considered exploiting it commercially. Many had not tasted it.

The average size and weight ratios of the sexes of the two lobster species were exactly opposite. Adult male spiny lobsters averaged larger and heavier than females, whereas adult male sand lobsters averaged smaller and lighter than females. The meat yield was better from the females in both species, but the highest yield was obtained from female sand lobsters.

Average percentage meat yields were:

	Male	Female
	Percent	Percent
Spiny lobster.....	26	33
Sand lobster	33	45

It is common knowledge that spiny lobsters normally live close to rocks or coral, which provide some degree of protection. This was found to be true during the period covered by this report. However, sand lobster movements appeared to be less restricted than those of spiny lobsters, because they were captured in the trawl and on mud bottom up to 5 miles from land or rock formations.

To determine if there was any difference in the day versus the night trawl catch rate, a comparative tabulation was made of the catch results and a graph was constructed (fig. 21). Of the 45 drags made, 4 were considered inconclusive and their results were not used in the computation. In addition, 144 of the 1,035 spiny lobsters were caught in traps during the first few days of the trip and, therefore, were not also used in the computation. Twenty-five drags (37.2 fishing hours) were completed in the daytime and 16 (24.5 fishing hours) at night for a total of 41 drags (61.7 fishing hours). Eight hundred seventy-four spiny lobsters were caught in the 41 completed tows. Of these, 547 (63 percent) were caught during the day and 327 (37 percent) at night. A total of 1,779 sand lobsters were caught in the same 41 drags of which 1,031 (58 percent) were caught during the day and 748 (42 percent) at night. As 60 percent of the fishing was done in the daytime and 40 percent at night, the results indicate round-the-clock trawling for lobsters would be feasible.

Panama Bay Scallops

One of the routine functions of exploratory fishing is to gather as much information as possible regarding the fauna observed in the daily operation. Thus, during cruise 15, when one drag for bait in 6 fathoms of water

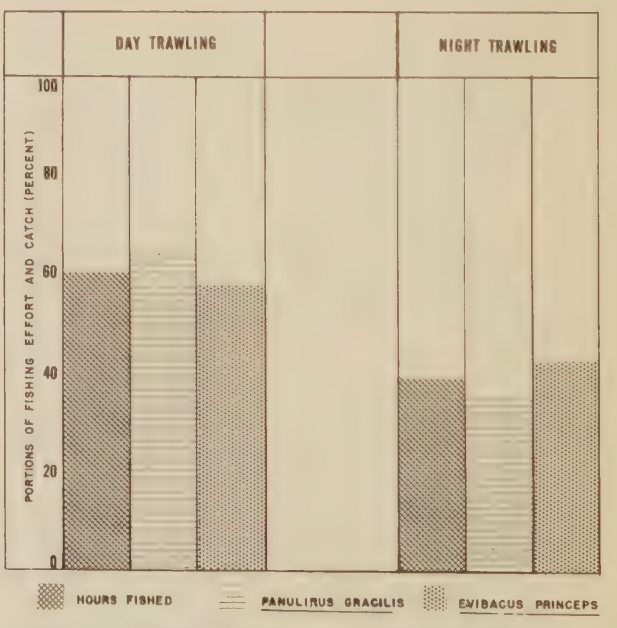

Figure 21.--Graph showing the similarity between the fishing effort and the catch results from day and night trawling for the Pacific Ocean lobsters, P. gracilis and E. princeps.

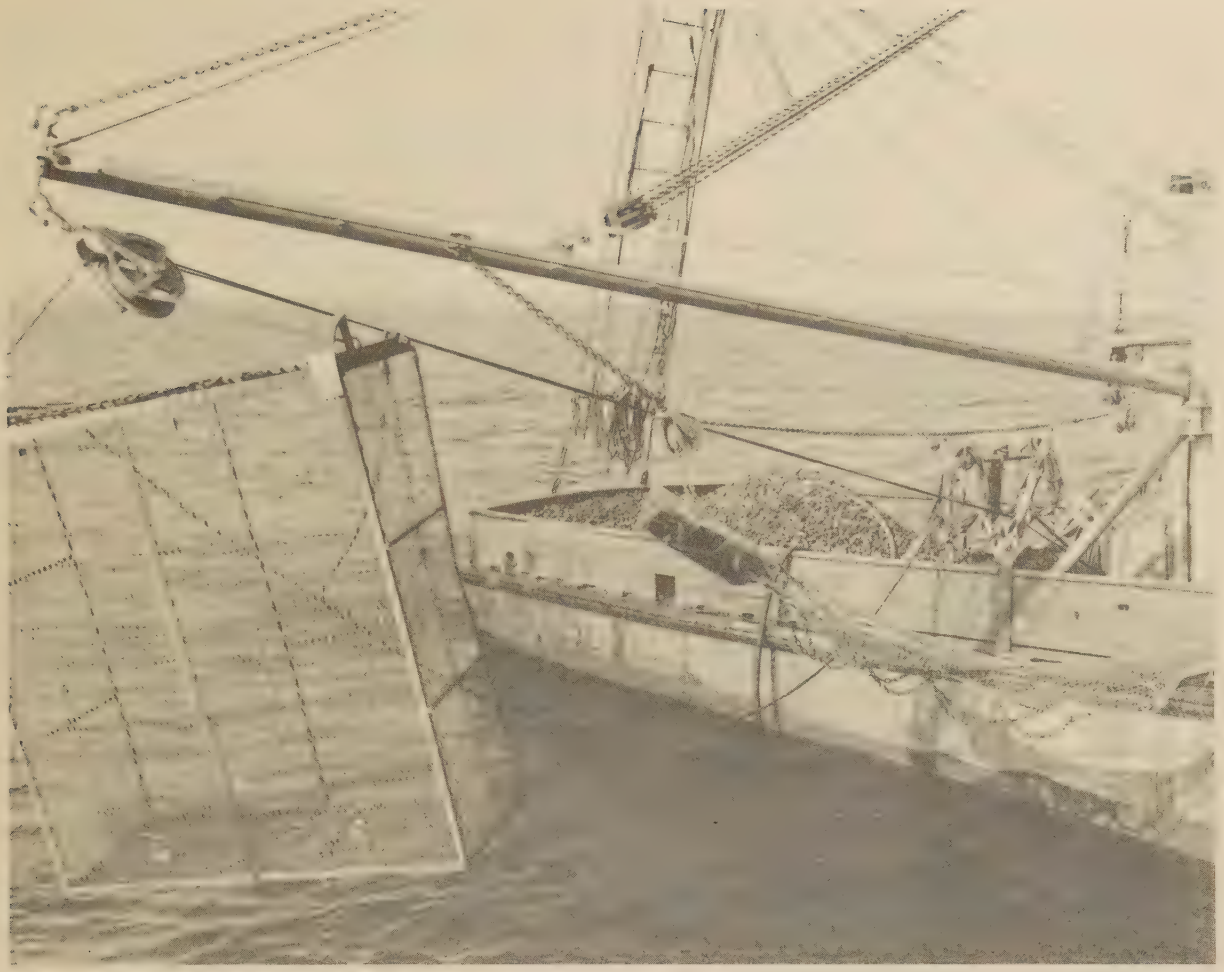

Figure 22.--A shrimp trawler equipped with a 6-foot, reinforced, expanded metal scallop dredge working the scallop beds found by the R/V Pelican in the Gulf of Panama. A deck load of the bay scallop (Aequipecten circularis) can be seen.

in the Gulf of Panama produced 4 bushels of bay scallops, their meat yield and quality were checked and noted. This information was passed on to the local fishing industry, whose reaction to the news was almost immediate. Four shrimp trawlers were dispatched to the area and, using only shrimp trawls, caught more than 23,000 pounds of shell stock (whole scallops). One of the local shrimp plants made some rapid renovations which enabled a 24-hour continuous operation, employing more than 300 people, to process, pack, and freeze scallop meats. Within a short time, there were 15 trawlers (fig. 22) with crews averaging 6 men working the beds. A change of gear from trawls to a 6-foot, reinforced, expanded metal dredge enabled the vessels to double their production rate. During the first 2 months of operation, 658,161 pounds of shell stock were landed.[4]

[4]Personal communication from Juan L. Obarrio, Director, Department of Fishes, Panama.

BIOLOGICAL NOTES ON PANAMANIAN LOBSTERS

Because a developing lobster fishery would ultimately have to concern itself with some biological considerations, it had been planned to collect data that would lend itself to the industry. These data would include information on spawning activities and length and weight measurements. To derive useful information on spawning required collections for a full 12-month period. This was accomplished for one of the three species of lobsters that were found in commercial quantities in Panamanian waters, the Pacific spiny lobster, P. gracilis. Owing to adverse weather conditions and the geographical distances involved, an insufficient amount of spawning data was collected for the Caribbean species of spiny lobster, P. argus. Because the Pacific sand lobster, E. princeps, was not located in commercial quantities until just prior to the project's end, there was no opportunity to

collect the necessary seasonal information. An indication that additional species of lobsters might be available was revealed by the capture of one specimen of a small species of spiny lobster, P. guttatus, and one specimen of the Caribbean sand lobster, Scyllarides aequinoctialis, in 8 fathoms off the northwest coast of Panama.

With the exception of a portion of the trawl catches, all lobsters were separated by sex, weighed, and measured. The maturity stage of the female lobster was noted. The total weight was recorded to the nearest ounce, and the dorsal length of the carapace was recorded in millimeters. These data have been compiled, and the more salient aspects are given separately for each of the three species of lobsters.

Spiny Lobster--Life History Notes

Spiny lobsters are usually found in rocky bottom areas, which provide them with protection from large predacious fish, including snapper, groupers, and sharks. Their best defense against these predators, when they are exposed in unprotected areas, is their long spiny antennae and their ability to swim backwards with short bursts of speed. They normally are nocturnal and forage primarily for stationary or slow moving marine organisms. They have strong mouth parts and are capable of crushing shellfish, which they use as a source of food.

The sexes are separate and can be determined by the location of the genital duct openings. These are located for the female at the base of the third pair of legs and for the male at the base of the fifth pair. Also, the paired swimmerettes of the female are large and overlap while the male swimmerettes are small and do not overlap.

Templeman (1940) reported from experiments with the American lobster that mating usually takes place a few hours after the female has molted and is still in a soft-shell condition. A limited number of field observations indicate that this probably holds true for the spiny lobster also. During mating, the male deposits a white viscous substance containing sperm on the ventral side of the female's thorax. The outside of this sperm sac hardens and becomes dark. The female retains this sac until she is ready to fertilize her eggs. As the eggs are extruded, she releases the sperm by scratching open the sperm sac with the tips of her fifth pair of legs. It was noticed in Panama that the female usually opened the posterior end of the sperm sac first, working anteriorally until all the eggs were fertilized. The number of eggs produced varies, dependent to a large degree on the size of the female, for example, the larger the female, the more eggs produced. After the eggs are fertilized, they become attached to filamentous parts under the tail where they are protected and aerated by the large swimmerettes until hatched. The newly deposited eggs are bright orange, but as the embryos develop, the eggs become brown. Smith (1959) states the eggs of P. argus turn almost colorless just before hatching. This condition was not observed among the Pacific spiny lobsters examined in Panamanian waters.

After the eggs hatch, the larvae spend several months drifting in the ocean currents. Thorson (1961) believes that panulirid larvae have a larval life of 150-180 days. Those larvae that survive change into a transparent form of the adult and settle to the bottom. They soon acquire lime that enables their shell or exoskeleton to become rigid, and assume adult coloration. Growth occurs after each molt, and the growth rate is dependent on the local environment.

Pacific Spiny Lobster (P. gracilis)

For convenience and clarity, the ratios of gravid and nongravid female lobsters from the inshore fishing areas are arranged in 3-month periods (fig. 23). As only one offshore trawling cruise was made, these data are, as indicated, limited to 1 month. The term gravid, as used here, includes both the berried (egg-bearing) lobster and those with sperm sacs, because we observed during field examinations that those female lobsters which had sperm sacs were in a ripe or ripening condition and would shortly be releasing eggs. Only adults were included in the nongravid category. The data from the juvenile catch were not used.

The inshore fishing was conducted primarily between 5 and 10 fathoms and from 50 yards to 1 mile from land. Because of the extensive Continental Shelf in the Gulf of Panama, the offshore fishing was also in the 5- to 10-fathom depth range, but the distance from the nearest land varied between 2 and 5 miles.

Gravid and nongravid females were taken from inshore waters throughout the year (fig. 23). Proportionally, these two categories varied only slightly. The percentage of all the inshore catch results for the entire survey period were 47 percent gravid and 53 percent nongravid. As there are no pronounced seasonal temperature changes which might affect the lobster's environment such as occur in the temperate zones, spawning continues throughout the year. Conversely, the offshore catch results showed a wide margin between the two conditions. The figures for that area are 92 percent gravid and 8 percent nongravid. Although there was time for only one trawling cruise, the results showed gravid lobsters, in significant amounts, offshore. If it could be determined that an offshore migration coincides throughout the year with the

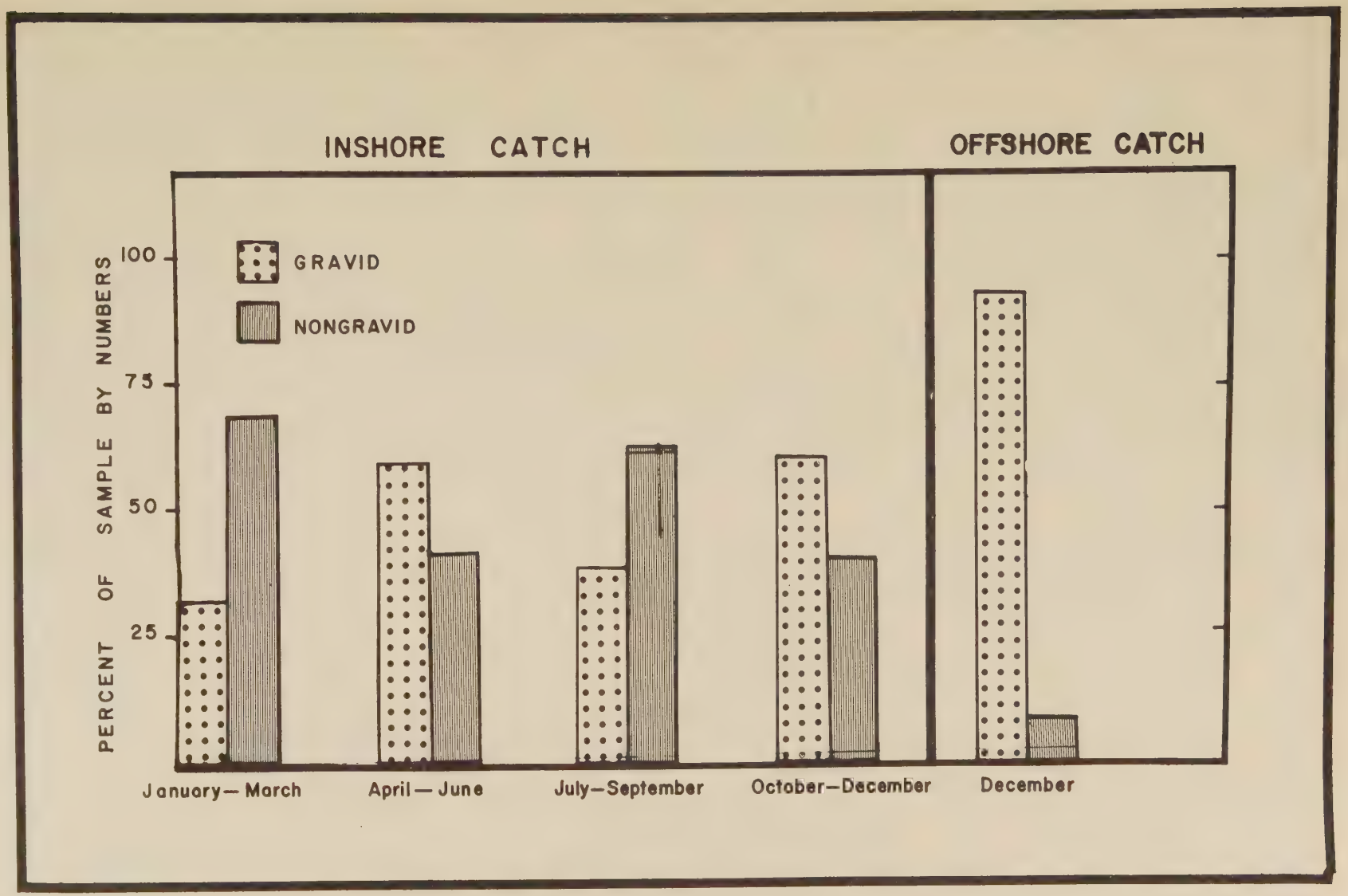

Figure 23.--Percentage of the gravid and nongravid female Pacific spiny lobsters (P. gracilis) taken during inshore and offshore fishing.

continuous spawning as reported here, it would be a significant contribution to a commercial fishery interested in maintaining a steady lobster population.

Previous workers have reported spiny lobster spawning primarily between March and July in Florida and the Bahamas, with the peak occurring during April. There are also reports that small numbers of gravid females could be found during the rest of the year. California spiny lobsters were found to have the same March through July spawning period. It was apparent in Panama that no single pronounced spawning period took place but that spawning occurred year round. During the second and fourth quarters, the ratio of gravid females was higher than the non-gravid. However, the relatively large number of gravid females caught during the first and third "slack" quarters indicates that no genuine peak does occur.

Figure 19 shows the inverse relation between male and female lobsters caught from the inshore and offshore waters, with fewer females than males being caught inshore and the opposite being true offshore. Dawson and Idyll (1951) suggest that the smaller proportion of females from inshore waters may result from their migration beyond the usual fishing areas during spawning season. Taking into consideration that gravid females were found year round, some of the results of this survey confirm their suggestion. These results are as follows:

1. More males than females were consistently found in the conventionally fished inshore lobster areas.
2. More females than males were caught during the offshore fishing.
3. Ninety-two percent of the offshore females were in a gravid condition.

Length frequency (fig. 24) and weight frequency (fig. 25) graphs comparing these characteristics for males and females were drawn. These show that males of 3-1/2 inches (9 cm.) carapace length, with a total weight of 20 ounces and females 2-15/16 inches (7.5 cm.) and weighing 15 ounces were predominant in the lobster population. The largest male weighed 4 pounds and the largest female weighed almost 2-1/2 pounds. The smallest egg-carrying female had a carapace length of 2-1/8 inches (5.5 cm.) and weighed 7 ounces.

A curve was constructed using the total weight and carapace length of the male and female lobster (fig. 26). It shows that for the lobsters caught during this survey, the males grew up to one-third larger and became almost twice as heavy as the female. However, up to a weight of about 2 pounds, the female was consistently found to be heavier than a male of equal carapace length.

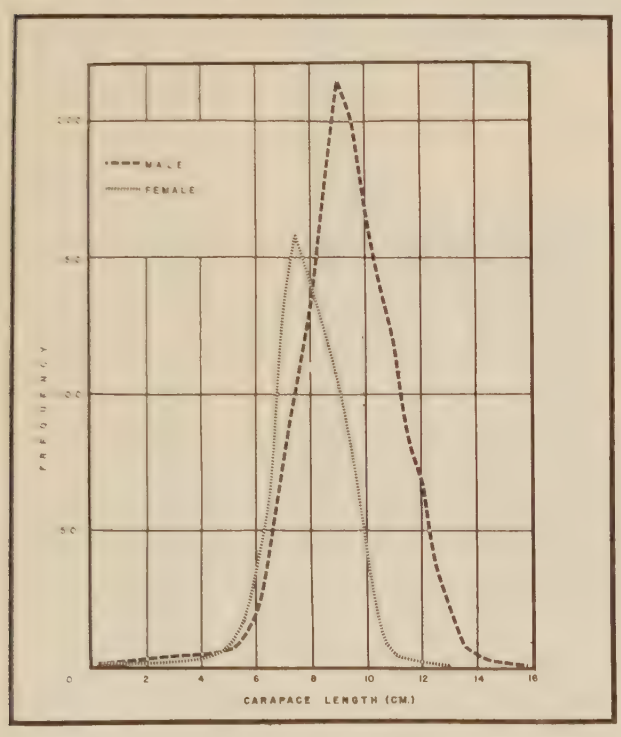

Figure 24.--Length frequency, by sex, of the Pacific spiny lobster (P. gracilis).

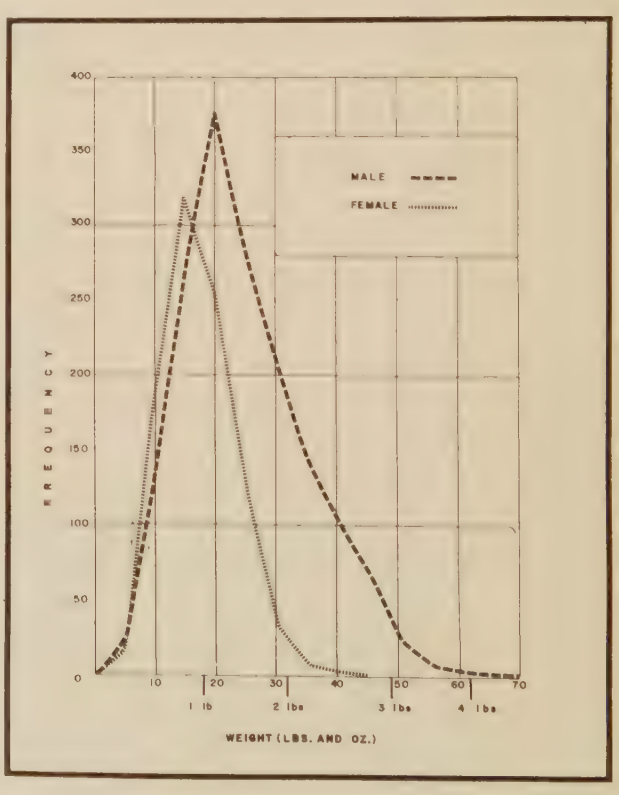

Figure 25.--Weight frequency, by sex, of the Pacific spiny lobster (P. gracilis).

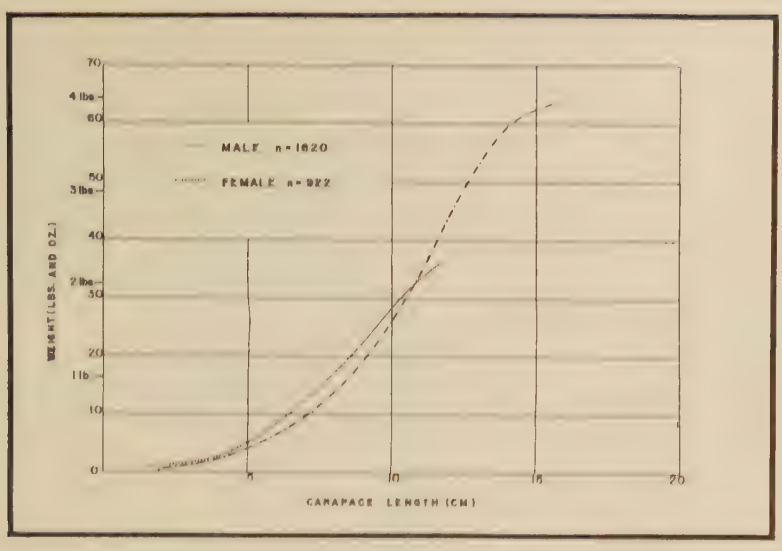

Figure 26.--Comparison of total weight and carapace length of the male and female Pacific spiny lobster (P. gracilis).

Caribbean Spiny Lobster (Panulirus argus)

Because of the limited period devoted to work on the Caribbean side of Panama not a great many lobsters were collected. All data for tabulation came from fishing in March and April, and although some traps were set out to a depth of 18 fathoms, all captured lobsters came from traps that had been set close to land, within a depth of 10 fathoms.

The male-female ratio of the catch made during this period showed that the sexes were almost identical in number--360 male and 357 female. This was in contrast to the inshore catch ratio of the Pacific spiny lobster which was 62 percent male and 38 percent female. And, as we also found in the other lobsters, the meat yield was higher from the female (35 percent) than the male (32 percent).

The increases of total weight and carapace length of the male and female are shown in figure 27. When compared with the graph of the Pacific lobster (fig. 26) the early weight-carapace length relations for both the Pacific and Caribbean species appear to parallel one another. The smallest egg-carrying female captured had a carapace length of 2-3/4 inches (6.9 cm.) and weighed 11 ounces.

Length frequency and weight frequencies (figs. 28 and 29) were constructed for males and females. These show the predominant size for the males to be 3-3/4 inches (9.5 cm.) carapace length and the weight at that length to be 25 ounces and for females 3-1/2 inches (9.0 cm.) and 25 ounces. When comparing the above data with those obtained for the Pacific lobster, some interesting differences are disclosed. Although the maximum sizes attained for the two species are similar, the predominant size of the Caribbean lobster found off Panama was larger than the Pacific lobster. Also, the female Caribbean lobster was found to be less evenly distributed throughout its entire size range than the male.

Of the 357 female Caribbean lobsters caught, we have no data for 38. Of the remaining 319, there were 204 (64 percent) gravid and 115 (35 percent) nongravid.

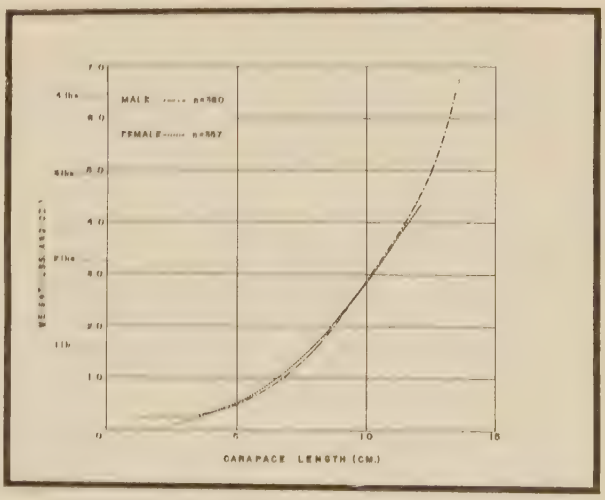

Figure 27.--Total weight and carapace length of the male and female Caribbean spiny lobster (P. argus).

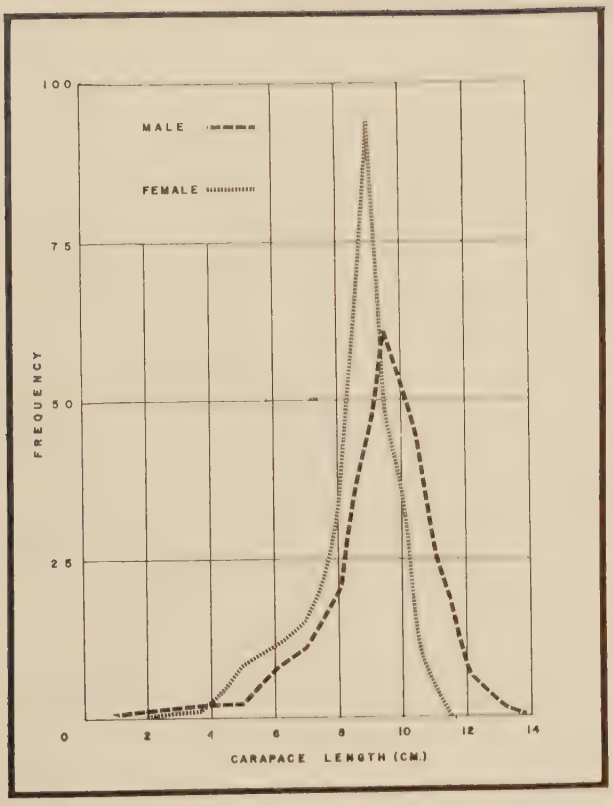

Figure 28.--Length frequency of the Caribbean spiny lobster (P. argus).

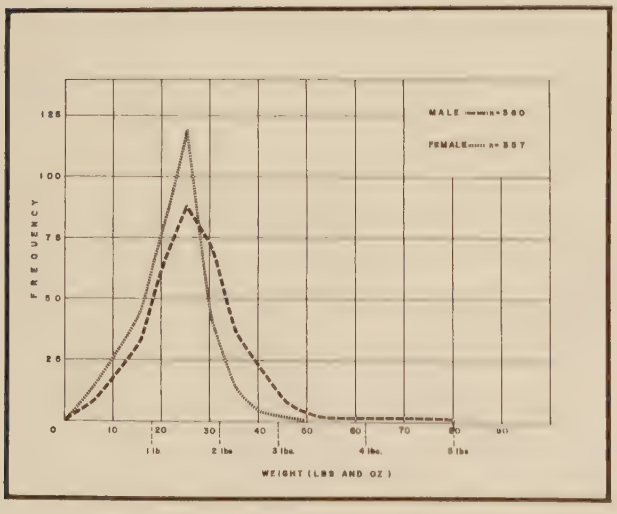

Figure 29.--Weight frequency of the Caribbean spiny lobster (P. argus).

Pacific Sand Lobster (Evibacus princeps)

E. princeps belongs to a family of crustaceans composed of at least eight genera that have a worldwide distribution. E. princeps has been reported from lower California to Ecuador (Rathbun, 1910). It has been called by an assortment of common names such as sand lobster, rock lobster, shovel lobster, Spanish lobster, and bulldozer. On the Pacific side of Panama it is usually referred to locally as the Chinese lobster.

There is little indication that sand lobsters are used commercially in the Western Hemisphere. This might result from either unfamiliarity with its edibility or its unavailability in commercial quantities. In the Gulf of Mexico, a sand lobster (Scyllarus nodifer) is occasionally taken in shrimp and fish trawls; few are caught and the fishermen eat them all. E. princeps is available in commercial quantities in Panama and is caught regularly in the trawls of the local shrimp fishermen. Because no local or export market exists, however, the fishermen throw it back in the water.

The sand lobster is distinctly different in appearance from the spiny lobster (fig. 15). Its heavy, rigid shell is more depressed than that of the spiny lobster and its last two sets of legs, when extended, reach only slightly beyond the edge of the carapace. Its bilobed antennae are short and flattened and are as wide as the anterior portion of the head. The outer margins of the antennae are rounded. It is from these appendages that some of the common names such as shovel lobster and bulldozer are derived.

The same characteristics for the identification of the sexes which were given for the spiny lobster are true for the sand lobster. The genital duct opening for the male is at the base of the fifth pair of legs and for the female at the base of the third pair of legs. The swimmerettes of the male are small and do not overlap while the female swimmerettes are large and do overlap.

The larval development has been described for a related species, S. arctus, as reported by Gurney (1942), and closely parallels the larval development of the spiny lobster. However, the extremely limited amount of study devoted to this family of lobsters prevents any comprehensive discussion of their life history.

The weight-length relation of the male and female sand lobster shows that the female, after it reaches a weight of 5 to 6 ounces, becomes larger and heavier than a male of the

same length (fig. 30). The largest male caught weighed 17 ounces and had a carapace length of 4-1/4 inches (10.8 cm.). The largest female weighed 25 ounces and measured 4-3/4 inches (12 cm.). Length and weight frequency graphs show that the predominant size of the male was 13 ounces with a carapace length of 3-1/2 inches (9 cm.) and the predominant size female was 19 ounces with a carapace length of 4-1/8 inches (10.5 cm.) (figs. 31 and 32).

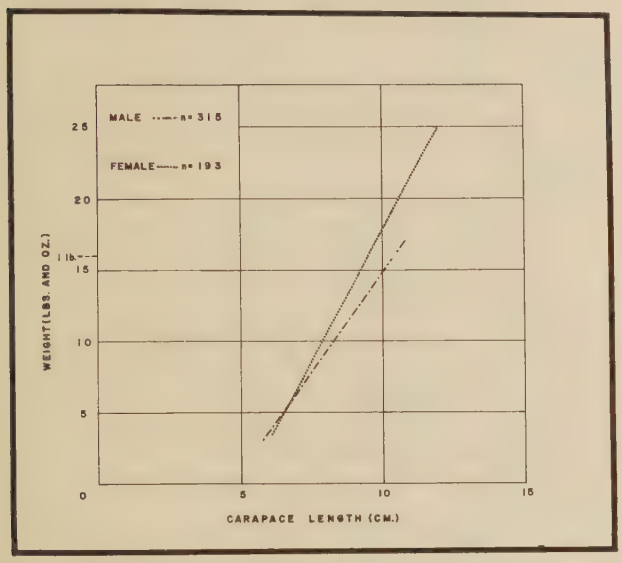

Figure 30.--Total weight and carapace length of the male and female Pacific sand lobster, E. princeps.

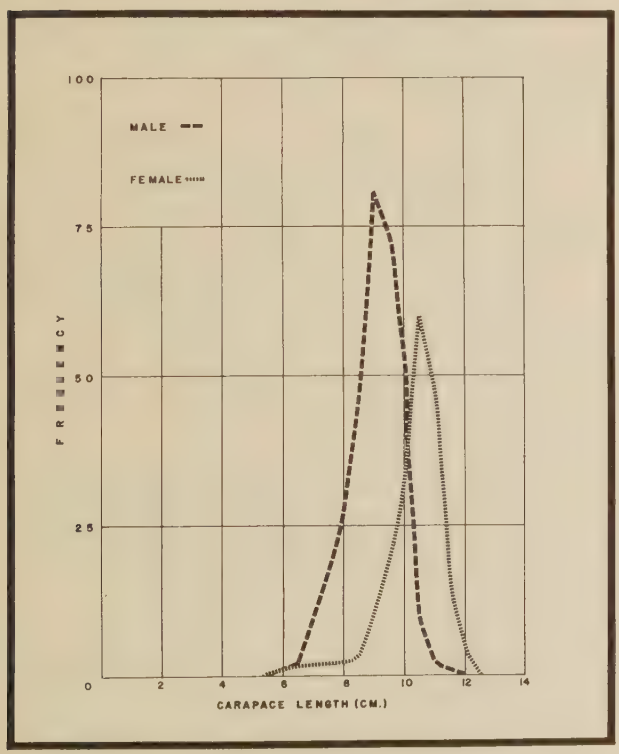

Figure 31.--Length frequency, by sex, of the Pacific sand lobster (E. princeps).

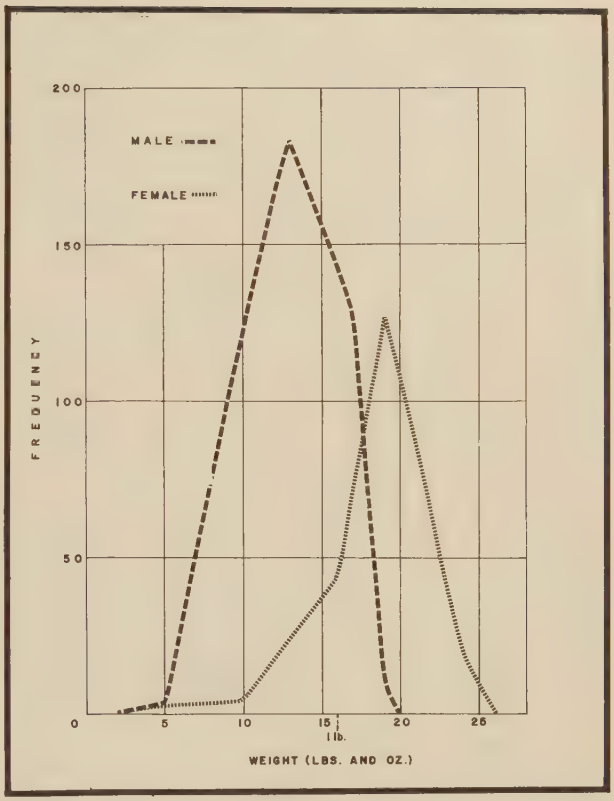

Figure 32.--Weight frequency, by sex, of the Pacific sand lobster (E. princeps).

SUMMARY

An interagency agreement, signed June 21, 1962, between the U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, and US/AID brought into being a survey of the spiny lobster potential in Panamanian waters. The work was carried out with the chartered vessel Pelican and Bureau staff members.

The explorations during the first year were confined largely to trap fishing owing to the flexibility of use, and for the reason that small and large operations could adopt traps should a resource be found. Traps of three types were used--reed, wire, and wood. Wood traps proved the most successful and practical. Traps in the water were located by means of a flag buoy attached to them. They were retrieved with a hydraulic trap hauler attached to a boom on the port waist of the vessel. Bait for the traps was taken in trawls, and on longlines, trolling lines, and handlines.

Because the entire coastline (Pacific and Caribbean combined) was too extensive to permit minute examination, representative areas were chosen on the basis of bottom topography, indication of lobster abundance from talks with fishermen, and nearness to population centers, sources of supply, and suitable vessels. In the Caribbean, the San Blas Islands and Bocas areas were surveyed; in the Pacific, the Gulf of Chiriqui and the

Gulf of Panama were the principal areas, though coverage was extended from these two areas toward Costa Rica and Colombia.

A number of environmental factors influencing lobster catches were investigated. It was found that traps set on the foraging area near reefs caught more lobsters than those set directly on reefs, or on flat bottom away from reefs. Bottom temperatures of 80° to 85° F., salinities of 31 to 32 parts per thousand, and depths of 4 to 5 fathoms appear optimum for lobster trap fishing.

No demonstrable preference for any one specific type of bait was observed.

Wood traps that were seasoned by submersion in the sea until coated with marine growths appeared more effective than unseasoned traps. Most efficient were 2- to 3-day trap sets.

During the survey, male lobsters outnumbered females and, on the average, were heavier and larger. Spawning appears to be continuous.

During the second year, commercial fishing was simulated to determine the lobster population density and to collect biological data of importance to commercial fishing endeavors. Two simulated commercial fishing cruises were conducted in the Gulf of Panama. Wood-slat lobster traps were used in the first cruise, and a modified shrimp trawl was used during the second cruise. Excellent spiny lobster catch results were achieved during both cruises. Commercial quantities of sand lobsters, for the first time, were caught during the second cruise. Three Panamanian, commercial lobster fishing enterprises were in various stages of development at the end of the project.

A bay scallop with commercial potential was found during routine operations of the first cruise. Within 2 months, over 400 people afloat and ashore were engaged in catching and processing scallop meats.

ACKNOWLEDGMENTS

In Panama, the office of the Minister of Agriculture, Commerce, and Industry, through its agencies, the Industrial Development Center and the Department of Fishes, provided cooperation and assistance that were immensely valuable.

LITERATURE CITED

BULLIS, HARVEY R.
1951. Gulf of Mexico shrimp trawl designs. U.S. Fish Wildl. Serv., Fish. Leafl. 394, 16 p.

BULLIS, HARVEY R., JR., and WARREN F. RATHJEN.
1959. Shrimp explorations off the southeastern coast of the United States (1956-1958). Com. Fish. Rev. 21(6):1-20.

CAPTIVA, FRANCIS J.
1955. Preliminary report on exploratory longline fishing for tuna in the Gulf of Mexico and the Caribbean Sea. Part II. Long-line gear used in yellowfin tuna exploration. Com. Fish. Rev. 17(10): 16-20.

COPE, C. E.
1959. Spiny lobster gear and fishing methods. U.S. Fish Wildl. Serv., Fish. Leafl. 487, 17 p.

DAWSON, CHARLES E., JR., and CLARENCE P. IDYLL.
1951. Investigations on the Florida spiny lobster Panulirus argus (Latreille). Fla. St. Bd. Conserv., Tech. Ser. 2, Mar. Lab., Univ. Miami, 39 p.

GALTSOFF, PAUL S.
1948. The pearl-oyster resources of Panama. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 28, 53 p.

GURNEY, ROBERT.
1942. Larvae of decapod crustacea. Ray Society, London, 306 p.

HALSTEAD, BRUCE W., and FINDLAY E. RUSSEL.
1956. Toxic marine organisms. In William S. Spector (editor), Handbook of biological data, p. 424-426. W.B. Saunders Co., Philadelphia and London.

RATHBUN, M. J.
1910. The stalk-eyed crustacea of Peru and the adjacent coast. Proc. U.S. Nat. Mus. 38 (1766): 531-620, pl. 36-55.

ROBINSON, RICHARD K., and DOLORES E. DIMITROU.
1963. The status of the Florida spiny lobster fishery, 1962-63. Fla. St. Bd. Conserv., Tech. Ser. 42, Mar. Lab., Inst. Mar. Sci., Univ. Miami, 30 p.

SMITH, F. G. W.
1958. The spiny lobster industry of the Caribbean. Fla. St. Bd. Conserv., Educ. Ser. 11, Mar. Lab., Univ. Miami, 34 p.

TEMPLEMAN, W.
1940. The life history of the lobster. Dep. Natur. Resourc., Newf., Serv. Bull. 15 (Fish.), 42 p.

THORSON, GUNNAR.
1961. Length of pelagic larval life in marine bottom invertebrates as related to larval transport by ocean currents. In Oceanography, No. 67, p. 455-474. Amer. Ass. Advance. Sci., Washington, D.C.

MS. #1429

GPO 890-710

Created in 1849, the Department of the Interior--a department of conservation--is concerned with the management, conservation, and development of the Nation's water, fish, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States--now and in the future.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES
WASHINGTON, D.C. 20240

OFFICIAL BUSINESS

Return this sheet to above address, if you do NOT wish to receive this material ☐, or if change of address is needed ☐ (indicate change).

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF THE INTERIOR

Library
BCF Biological Laboratory
P. O. Box 3830
Honolulu, Hawaii 96812
SSR 7